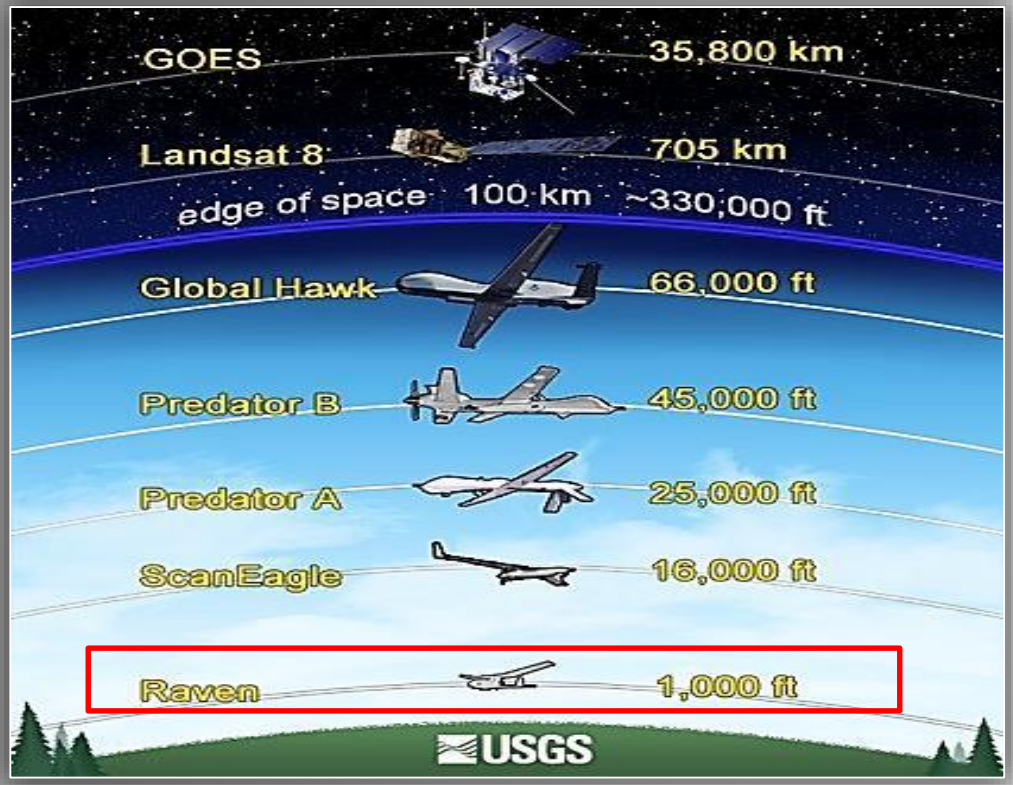
Department of the Interior
Small UAS Research Missions and Platforms

uas.usgs.gov

Jeff Sloan
Project Leader
USGS-Geosciences & Environmental Change Science Center
USGS National UAS Project Office
San Diego, CA
October 2016

Land Remote Sensing Program
National UAS Project Office

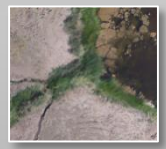
USGS UAS Focus:




Landsat 8
(30 meter)


NAIP/NDOP
(1 meter)


UAS at 400 ft
(5 cm)


UAS at 200 ft
(2.5 cm)

USGS UAS Milestones:

2003-2008 …..UAS Investigations
- 2008 ….. USGS National Project Office (Denver)
- 2009 ….. Raven Systems
- 2011 ….. 1st NAS Operations
- 2011 …… T-Hawk Systems

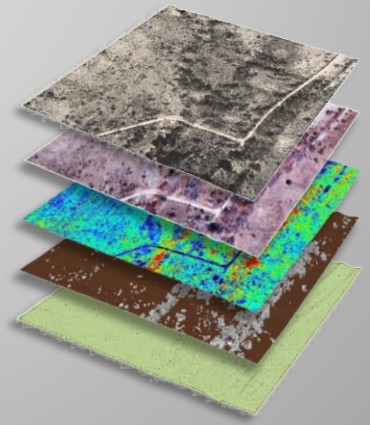
2012-2014 ….. FAA Approved DOI training & MOA
- 2015 …… New Systems Acquisition (3 categories)
- 2015 …… USGS UAS Workshop
- 2016 …… New Systems Acquisition (micro categ.)
- 2016 …… Ability to Contract with commercial UAS
- 2016 …… FAA Part 107

How to Make It All Work

- **Platform**

- **Sensor**

- **Data Processing**



Dept. of the Interior - UAS Platforms

2009-2015

AeroVironment – Raven RQ-11A

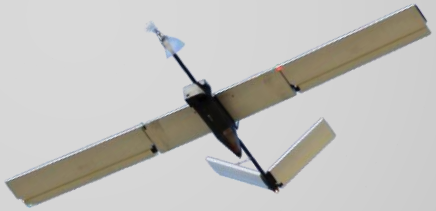
Honeywell - T-Hawk

MLB Super Bat

2015 - PRESENT

3DR Solo

Falcon Fixed Wing



Falcon Hover

Pulse Vapor 55

USGS science for a changing world

Sensors

Point & Shoot, MILC and DSLR Cameras

High Definition Video

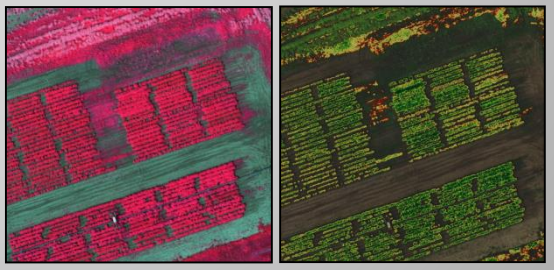
Thermal Sensor

FLIR

Courtesy of FLIR Tau 2 Sample Images

Multispectral Sensor

MicaSense



Courtesy of MicaSense Sample Images

USGS science for a changing world

Future Sensors

- **Geomagnetometers**
- **Hyperspectral Sensors**
- **Natural Color High Resolution Medium Format**
- **Telemetry**
- **Radar**

LiDAR

Hyperspectral

Magnetometers

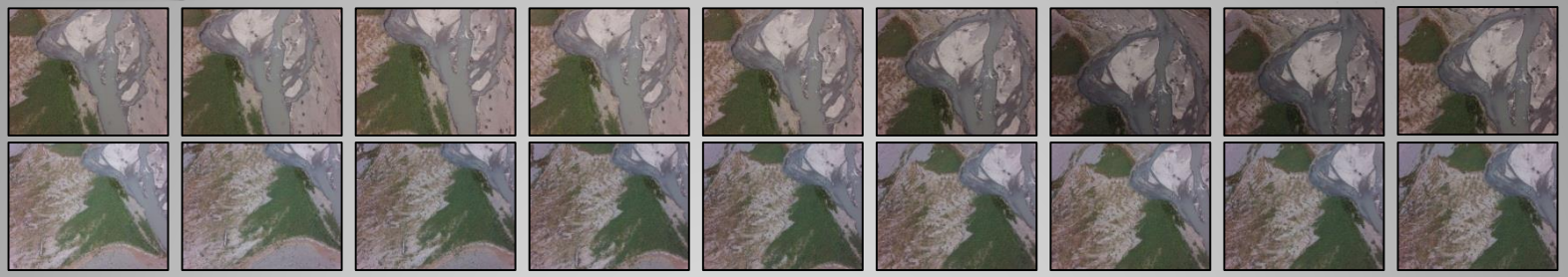
Medium Format

USGS science for a changing world

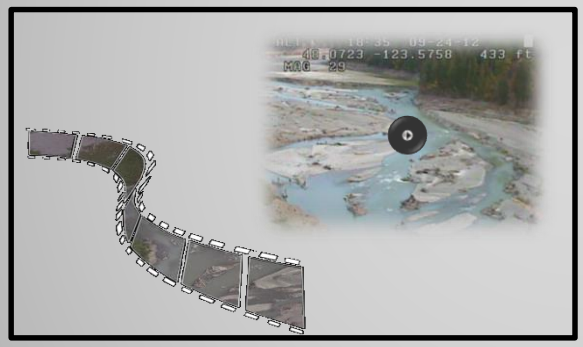
Geospatial Product Creation

With Data Acquired from UAS

(Computer Vision - Structure-From-Motion)

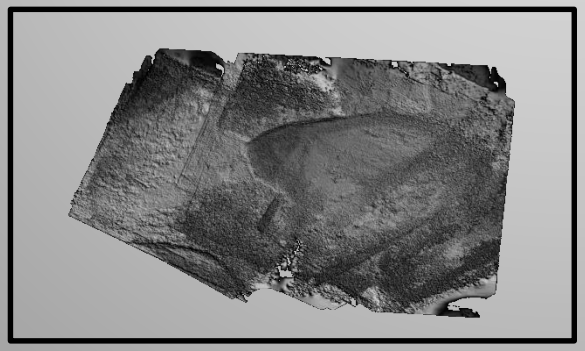


STILL FRAME IMAGES CAPTURED ON-BOARD THE UNMANNED AIRCRAFT

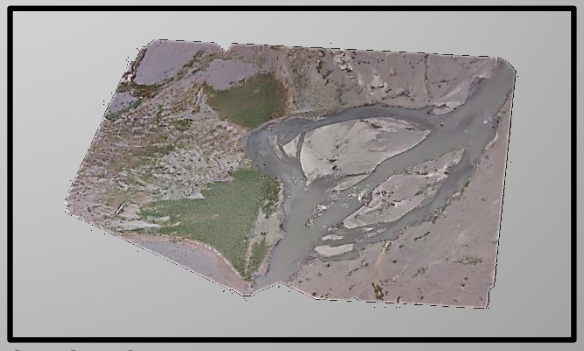


FULL-MOTION VIDEO

3-D POINT CLOUD DATA



ELEVATION MODELS



ORTHOIMAGERY

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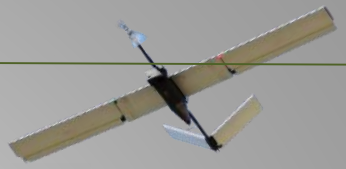
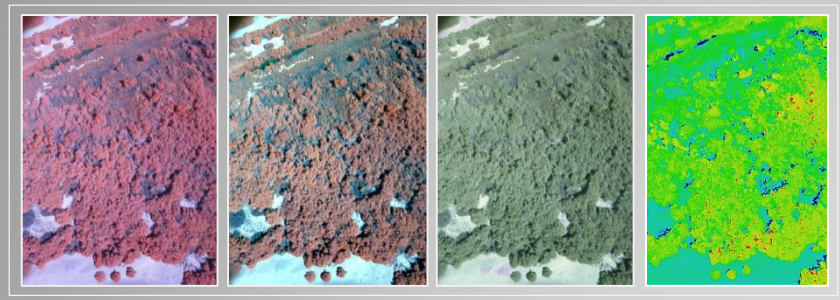
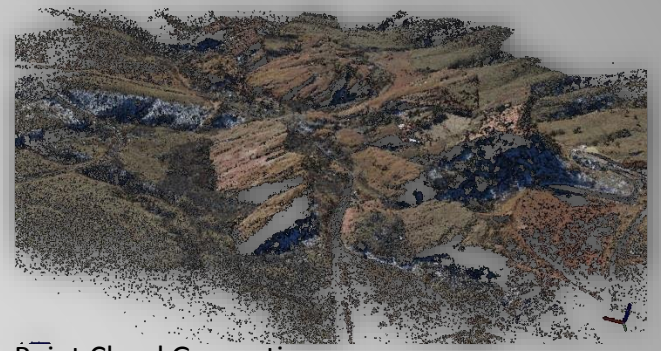
Derived Geospatial Products

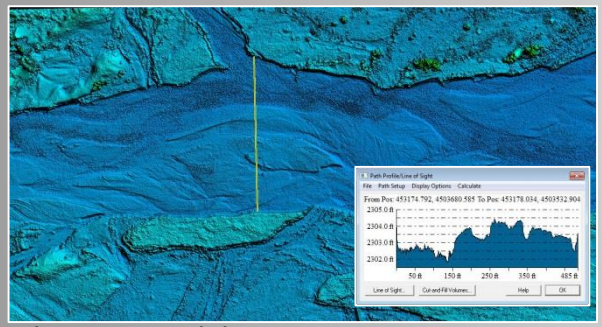




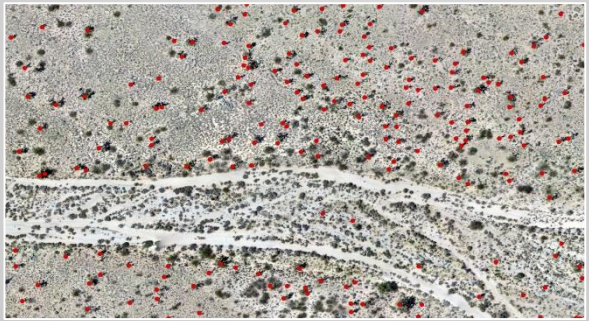
Color Infrared - NDVI



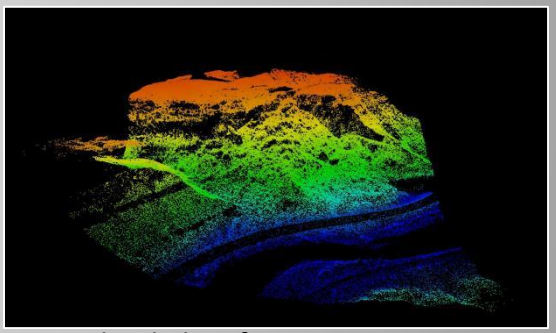
Point Cloud Generation



Elevation Models



Feature Extraction

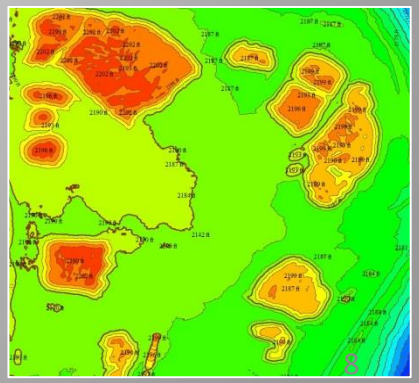


Point Cloud Classification

KML – 3D Modeling

Orthophotography

Volumetric Measurements



Contour Generation

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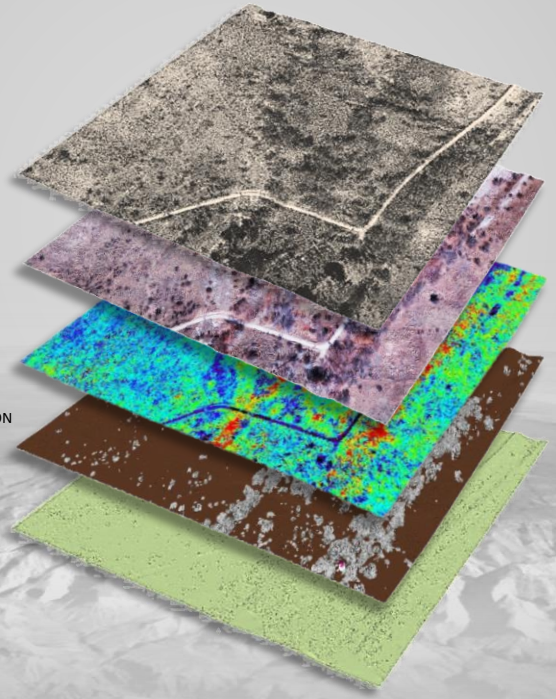
Derived Geospatial Products



3-D POINT CLOUD DATA

DIGITAL SURFACE MODELS

DIGITAL TERRAIN MODELS

ORTHOIMAGERY

SEGMENTATION AND CLASSIFICATION

Trumpeter Swan Nesting

Camas and Greys Lake NWR, Idaho

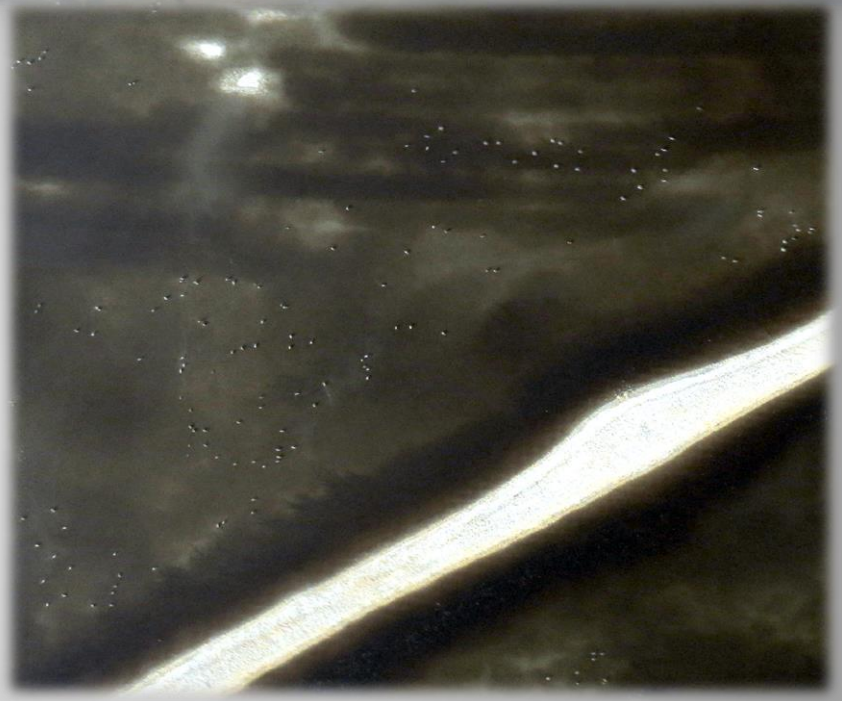
EO camera @400ft AGL from Canon s100 12MP

Tau 640 thermal-IR @400ft AGL from RAW 14-bit

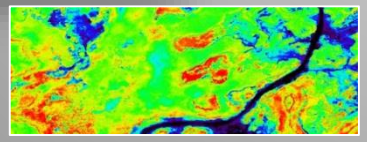
Waterfowl & Habitat Surveys

Ruby Lake, NV – Kern/Pixley, CA – Tomalas Bay, CA

Generating a census for waterfowl populations and determining individual species. Developing an UAS image library for waterfowl identification and mapping habitat.



From 1937 to 2000, 66% of all field biologist fatalities in DOI were aviation-related.



15 cm ZOOM					
Elevation (MASL)	158	138	120	102	85
M above ground	90	70	52	34	17
Ft above ground	295	229	170	112	56
Mallard					

Pelican Nesting Habitats

Chase Lake, North Dakota June 2014

Raven UAS image mosaic from the Sony ActionCam (2mp) from 400 ft. AGL

Elk Population Estimates

Idaho 2015

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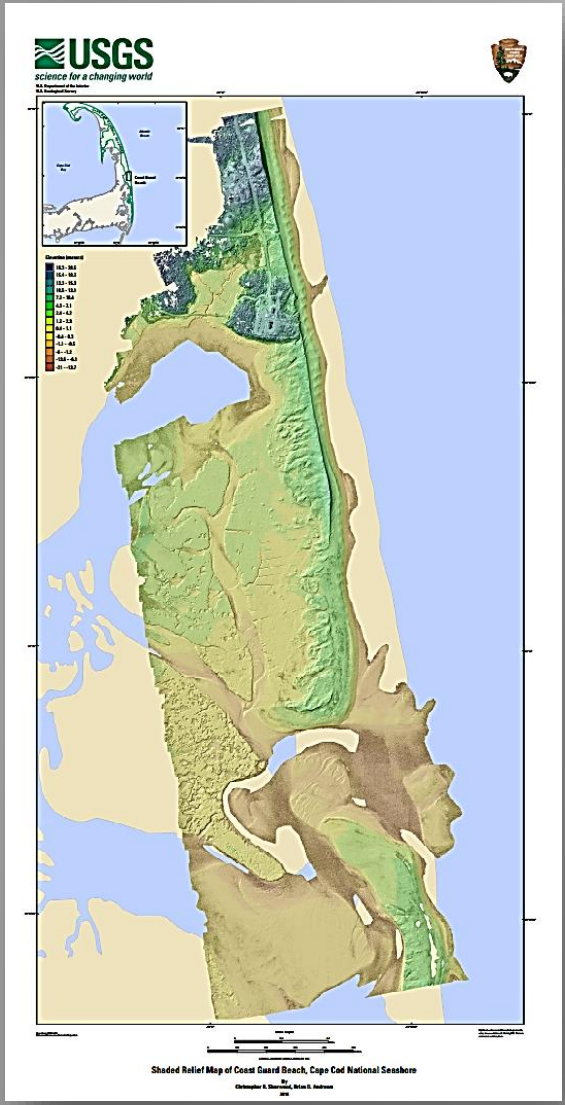
Coastal Applications

Cape Cod National Seashore, 2016



Shaded Relief Map of Coast Guard Beach
Cape Cod National Seashore
Sherwood & Andrews 2016

Overwash and erosion along beaches of Sandwich, Mass
Sherwood & Traykovski 2016

USGS
science for a changing world

Mine Inspections

West Virginia – First T-Hawk Mission in the NAS – Nov. 2012
(Office of Surface Mining, BLM, USGS)

Monitoring Mining Areas

Lead Mine Sinkholes, Missouri

Abandoned Mine Lands, Colorado

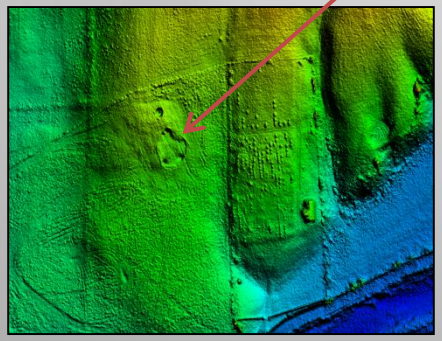
Coal Mine Reclamation Monitoring, West Virginia

West Fork Lead & Zinc Mine (Sinkholes)

Bunker, Missouri

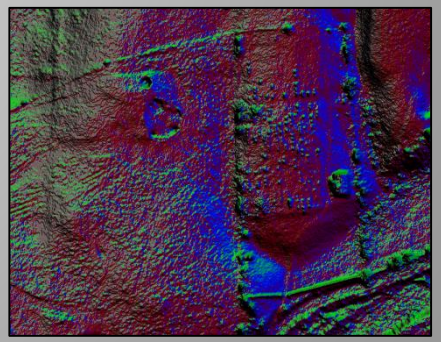
Sinkholes

Orthoimagery



Elevation

Slope



Aspect

Flying at 325 feet (100 m) Above Ground Level - 2 cm GSD - 2 cm horizontal accuracy and 4 cm vertical

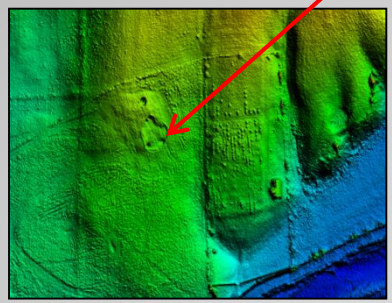
West Fork Lead & Zinc Mine (Sinkholes)

Bunker, Missouri

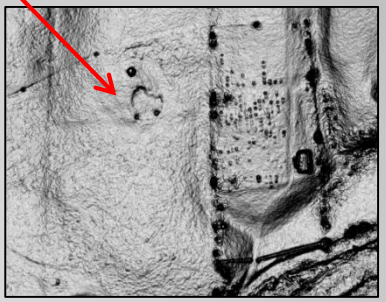
Flying at 325 feet (100 m) Above Ground Level - 2 cm GSD - 2 cm horizontal accuracy and 4 cm vertical

Orthoimagery

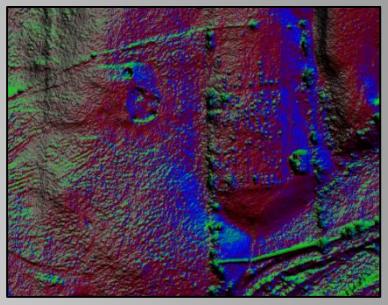
Elevation

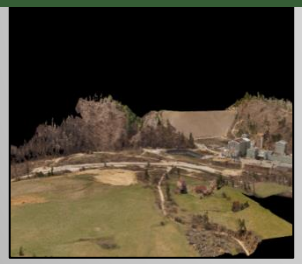
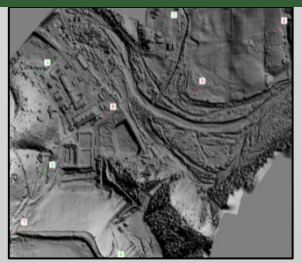
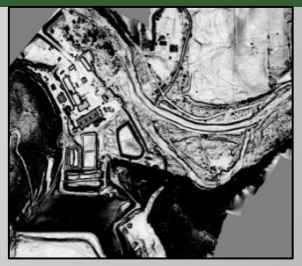
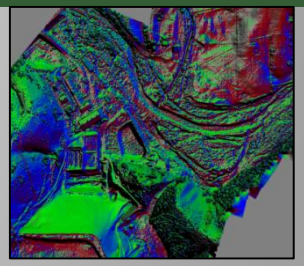
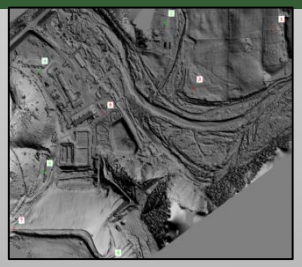
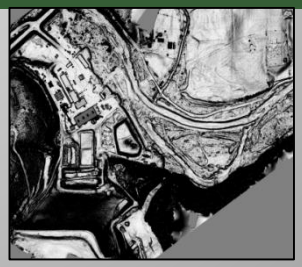
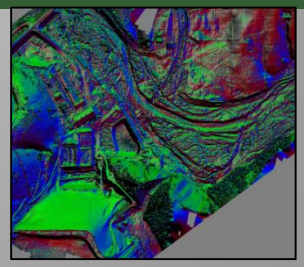


Slope



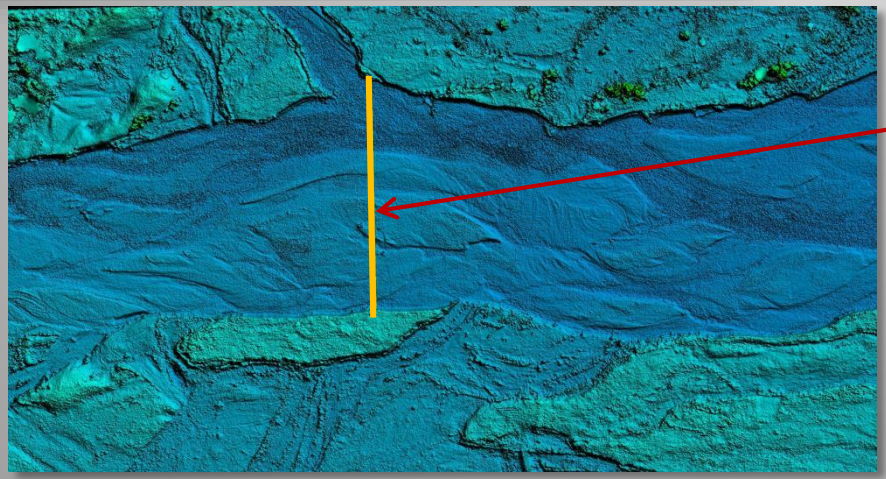
Aspect

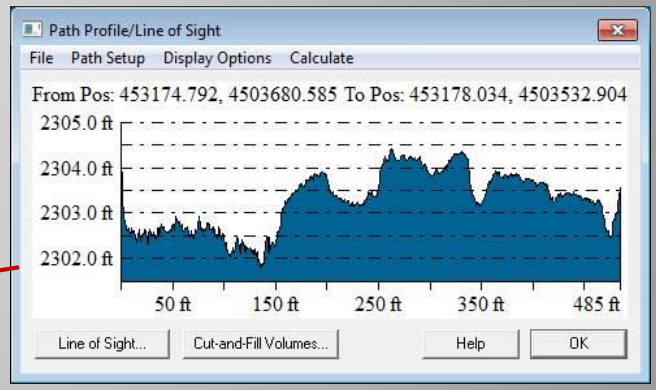


ORTHOPHOTO MOSAIC	DENSE POINT CLOUD	DIGITAL SURFACE MODEL	SLOPE VALUES	SLOPE ASPECT
DJI Inspire – Zenmuse X3				
				
DJI Inspire - Ricoh GR				
				

Emergent Sandbar Habitats

Platte River - Kearney, Nebraska

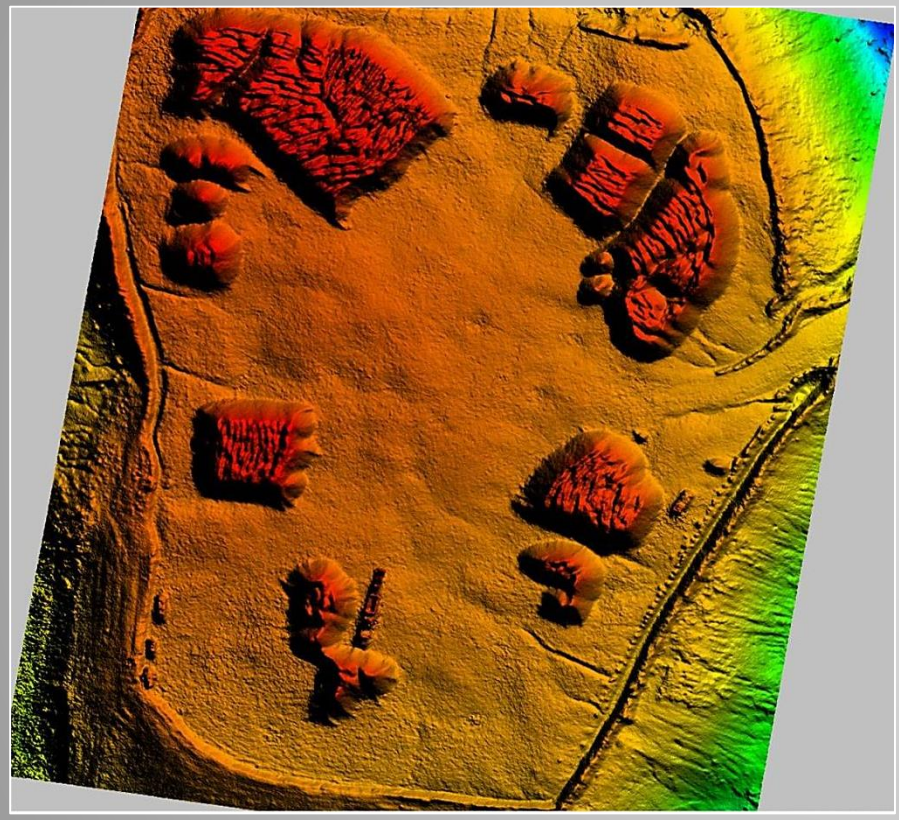




Mapping the spatial extent and elevation of emergent sandbars along two reaches of the Platte River for endangered or threatened nesting birds (least terns and piping plovers)

Mining Stockpile Volumetric Measurements

Kentucky – 2014



Digital Elevation Model Hillshade

Volumetric Measurements (Cubic Yards)

Debeque Landslide

Debeque, Colorado 2013

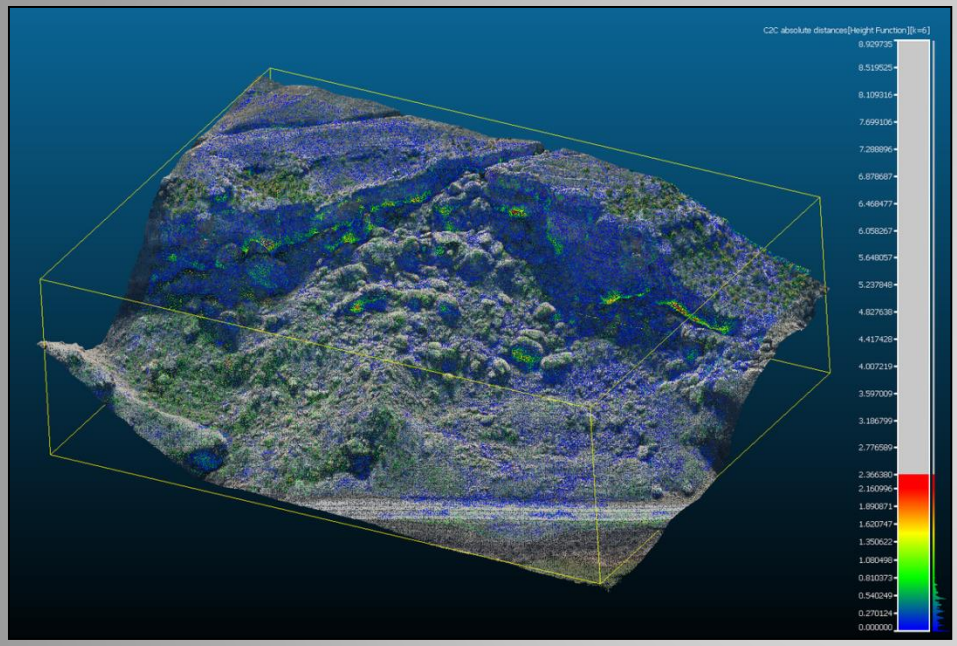
Temporal series of Landslide models monitoring geomorphic processes.

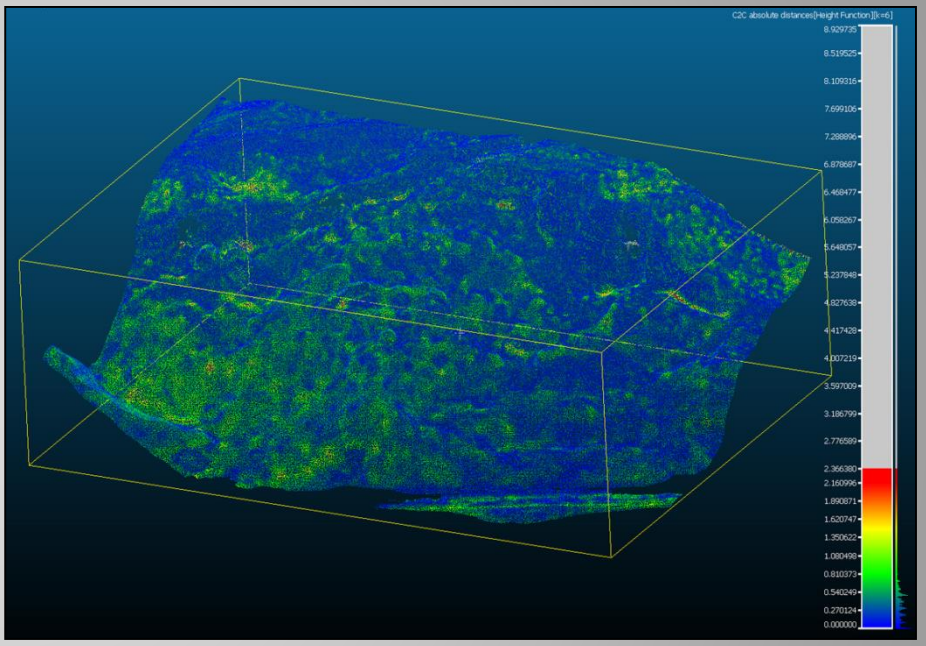
October 2013

USGS science for a changing world

Debeque Landslide

Debeque, Colorado 2013





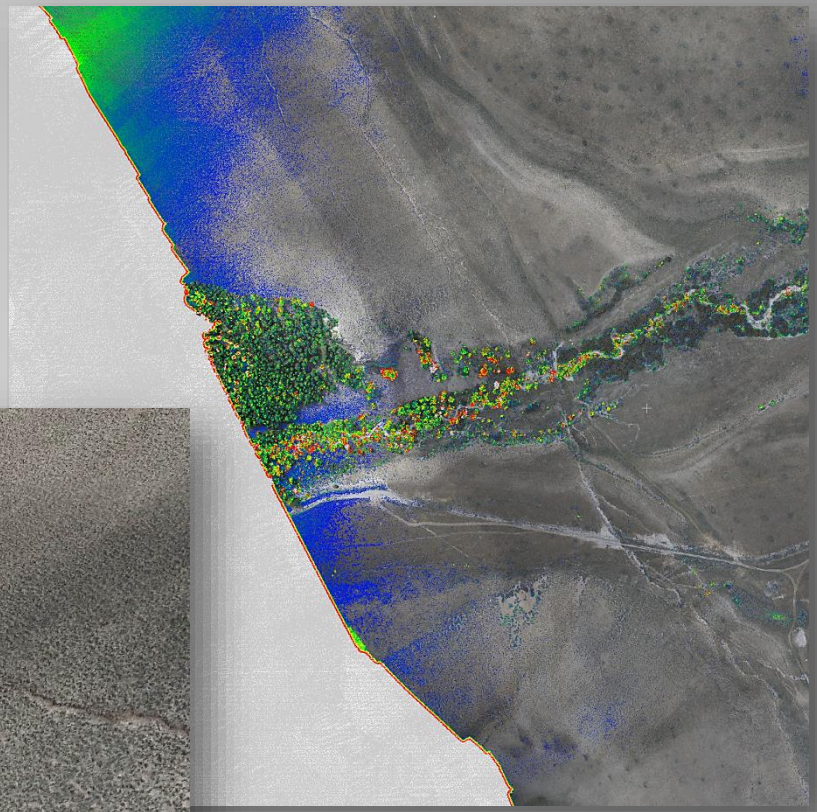
Green indicates possible movement over time

Point cloud comparison and calculations (using Cloud Compare)

Earthquake Fracture Modeling

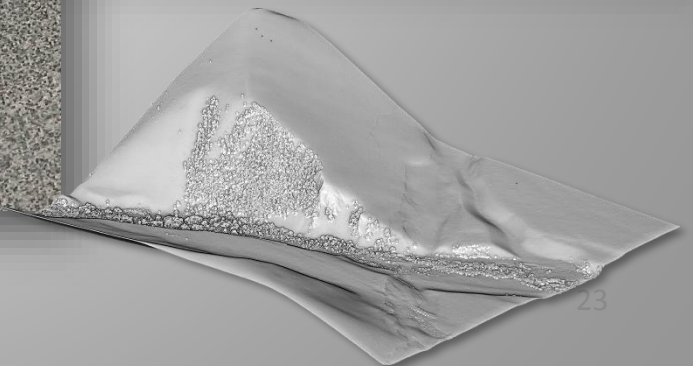
Borah Peak, Idaho

Comparisons between UAS Photogrammetric Point Cloud generation and Airborne LiDAR



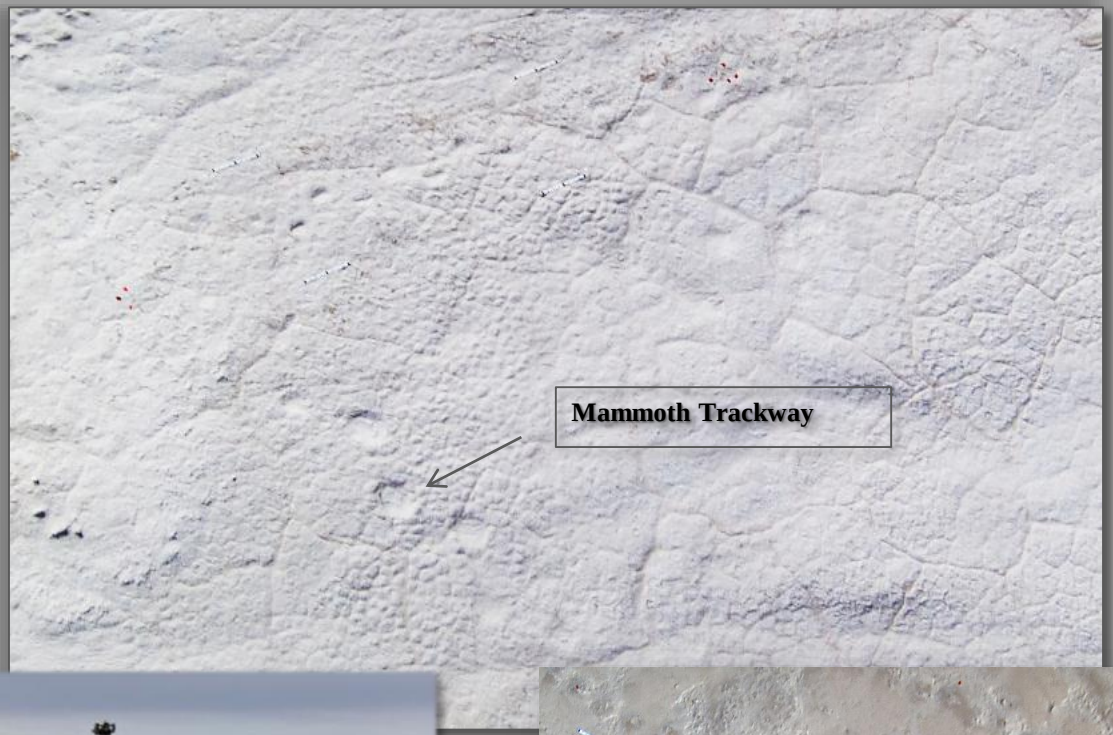
Colors indicate a 6-12” vertical difference

UAS Photogrammetric Point Cloud generated from images taken at 1200 ft. AGL



Pleistocene Trackway Mapping

White Sands National Monument, NM January 2014
(BLM & NPS)



Photogrammetric documentation using a UAS to aerial survey extremely fragile fossilized footprints from the late ice age.

USGS science for a changing world

Lake Havasu, Arizona

October 2014

WorldView 2 – Multispectral (pan sharpened)

UAS – Canon s100 (modified blue filter)

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UAS Data Processing

Color Infrared & Normalized Difference Vegetation Index (NDVI)

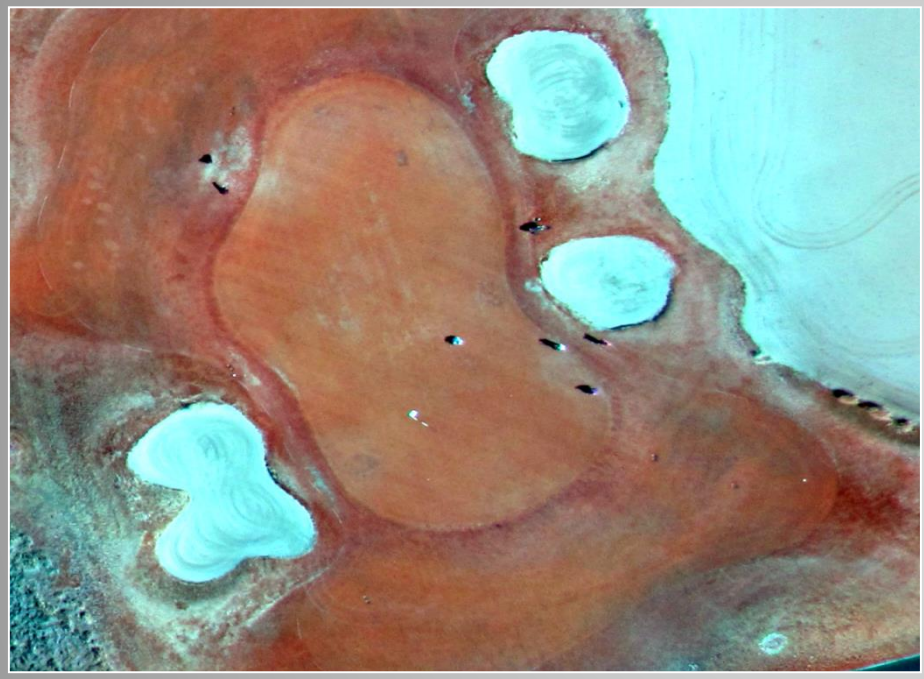
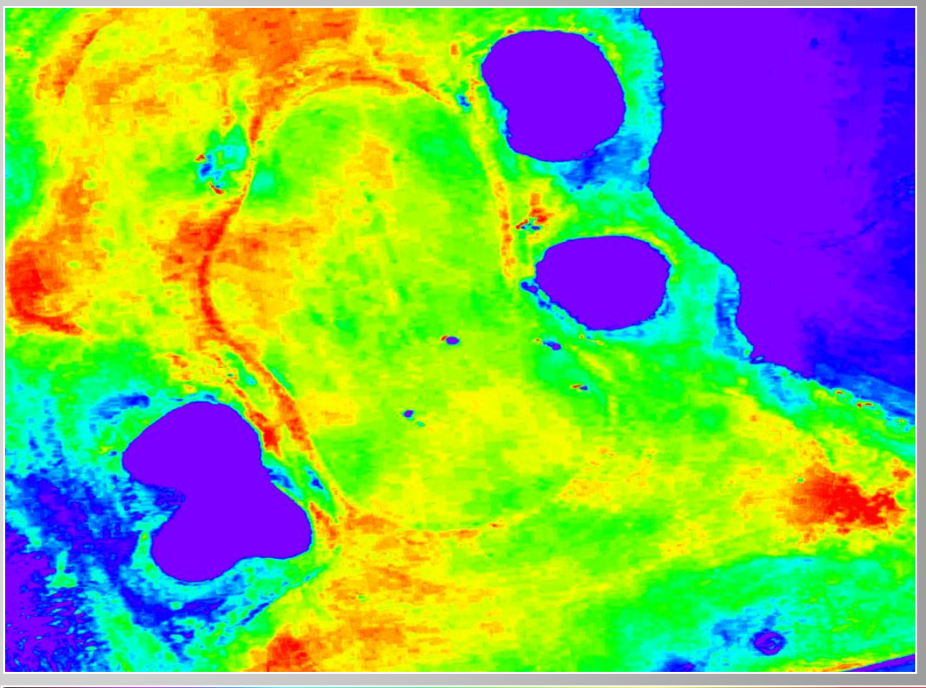


Image collected from UAS – Canon SX230 HS – 400’ AGL



NDVI Low NDVI High

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{VIS})}{(\mathrm{NIR} + \mathrm{VIS})}$$

Theodore Roosevelt National Monument

North Dakota – Aug. 2016

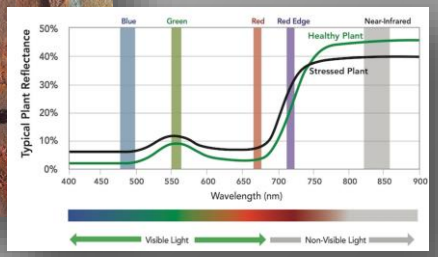
USGS science for a changing world

Theodore Roosevelt National Monument

North Dakota – Aug. 2016

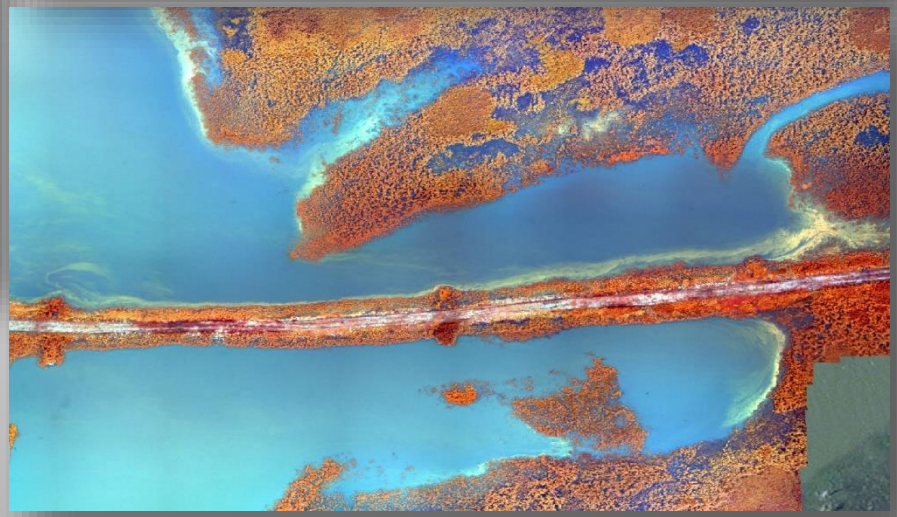
Sony A5100
Voigtlander Lens 15 mm
RGB (Bayer Filter)

Micasense Multispectral
RGB, NIR, Red Edge



Algal Blooms

Milford Lake near Manhattan, KS



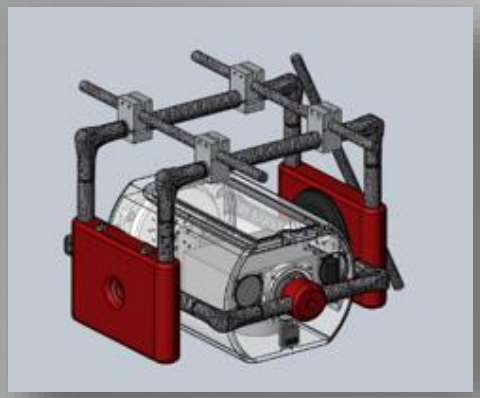
Algal Blooms

Milford Lake near Manhattan, KS

Micro UAS – 3DR Solo

Image courtesy 3DR

Cooperative Work - Academia



2-Axis Gimbal Setup

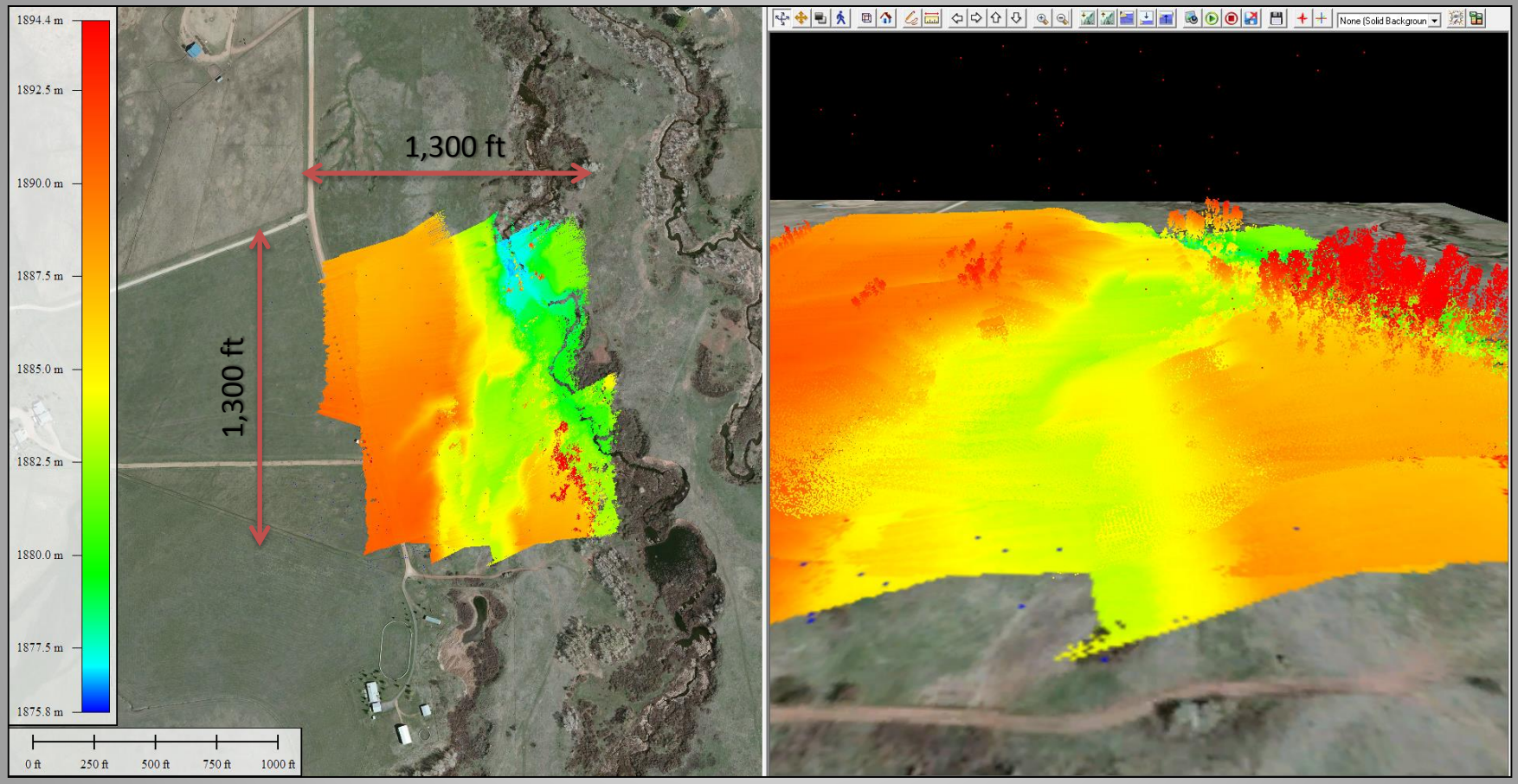
EO, TIR, hyperspectral and lidar sensors

UF UNIVERSITY of FLORIDA — Unmanned Aircraft Systems Research Program

USGS science for a changing world

Sensor Testing and Integration

Colorado 2016



Pulse Vapor 55 UAS

Multiple Payload Capability
(Simultaneous Data Collection)

Can the Work be Contracted?

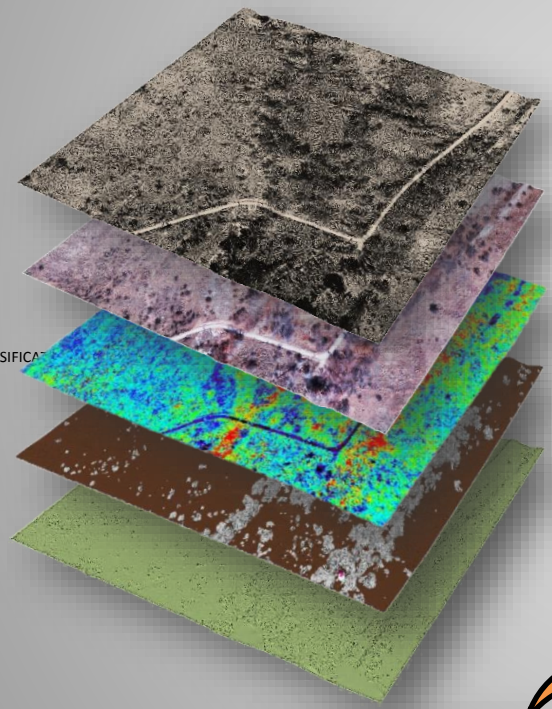
7,500+ Unmanned Aerial Systems with FAA Section 333 Exemptions for Commercial Work

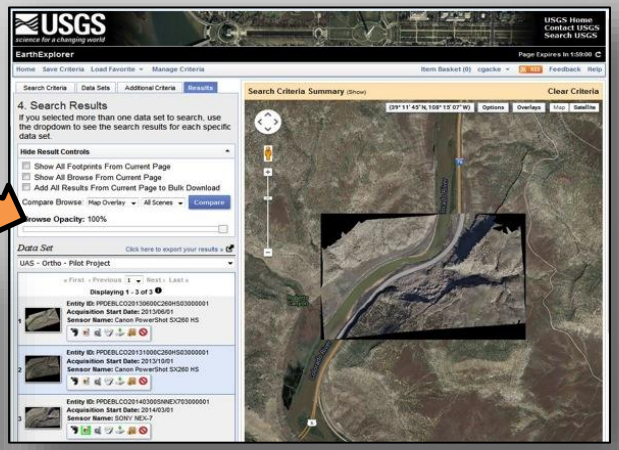
FAA Part 107 - New Rules for Commercial Operators – August 2016

UAS Data Access & Distribution

Data Dissemination & Archive

- Multiple copies are made at project site
- Derived data is given to PI
- Raw & Derived Data to EROS (metadata)
- Research data – Science Base
- Presidential Memo (*Economic Competitiveness while Safeguarding Privacy - Feb. 2015*)

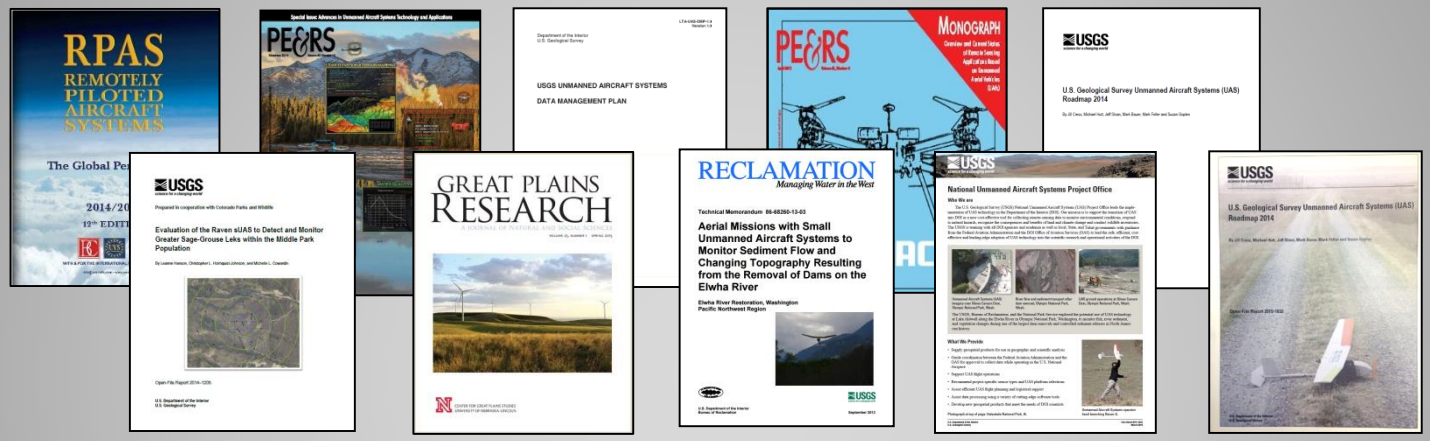




Distribution through The National Map - Earth Explorer

Can UAS Data Be Published?

Peer Reviewed Publications:



Mainstream Press:

New York Times, Air & Space, Unmanned Systems International, Earth Imaging Journal
National Geographic, Federal Times, NPR, Several Newspapers

USGS - Land Remote Sensing Program

National UAS Project Office – Strategic Planning

Mission Statement: *The USGS National Unmanned Aircraft Systems Project Office will lead the safe, efficient, cost-effective and leading-edge investigation of the potential uses for UAS technology in scientific research activities for the USGS and the Department of the Interior.*

Goal: *Implement UAS as a common tool for scientific research and operational activities.*

Objectives:

- ***Lead research and integration activities into UAS technology aimed at making it simply another efficient tool for DOI and USGS imagery acquisition including platform, sensors, and data processing techniques.***
- ***Perform proof-of-concept missions to support the development of operational procedures, evaluation of new technology, data investigations, and the establishment of operational benefits that could include increased safety, reduced cost, and improved data quality.***
- ***Develop leading-edge data processing techniques that use state-of-the-art computer concepts to develop traditional and newly created geospatial products routinely at increased resolutions and accuracies.***
- ***Investigate a complete vision of DOI UAS operations ranging from researching all related UAS technology, working with commercial UAS contracts, to collaborating with other agencies or universities in order to leverage the learned knowledge and rapid adaptation to the speed of the technology developments.***
- ***Provide access to office staff that are already recognized as subject matter experts within DOI and internationally in order to strive to serve as the DOI - Center of Excellence for Scientific Investigations of UAS technology.***

USGS science for a changing world

USGS - Land Remote Sensing Program

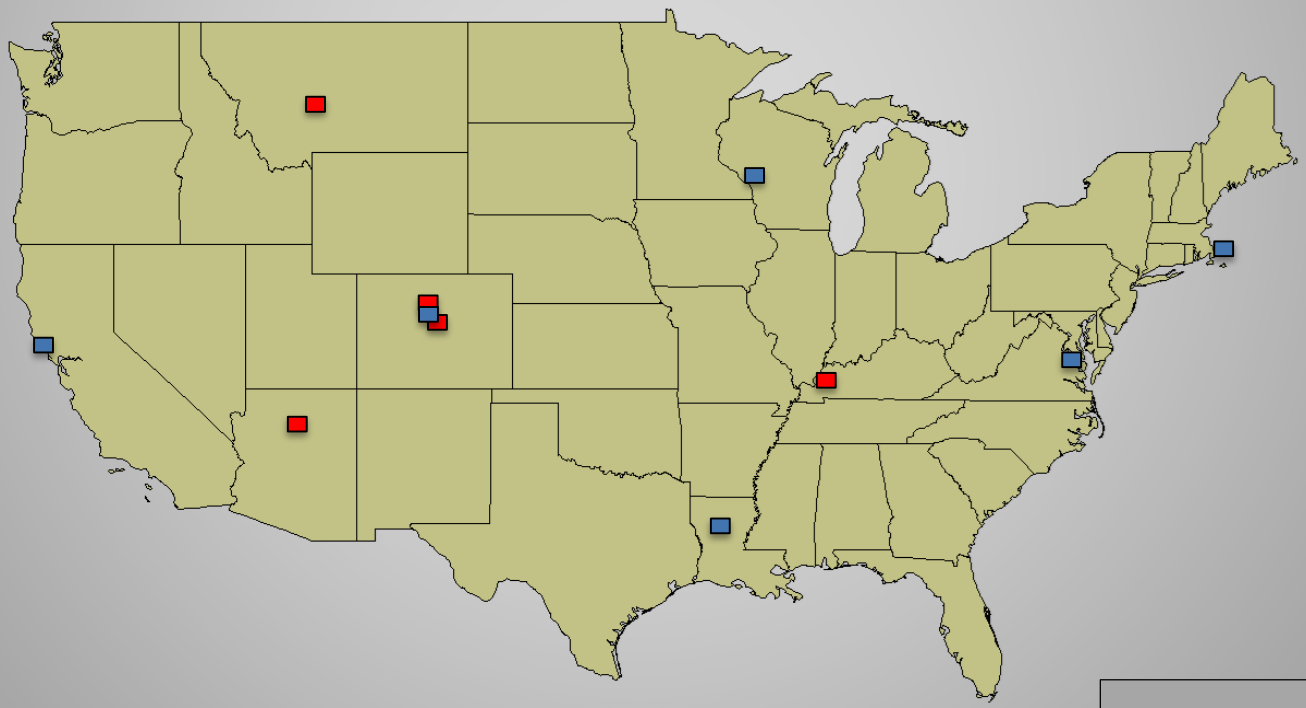
National UAS Project Office – Strategic Planning

Other organizations related work and cooperative efforts:

- ***Working with and supporting the establishment of operational USGS UAS groups***

  Active: *Flagstaff, Ft. Collins, Bozeman, Louisville*

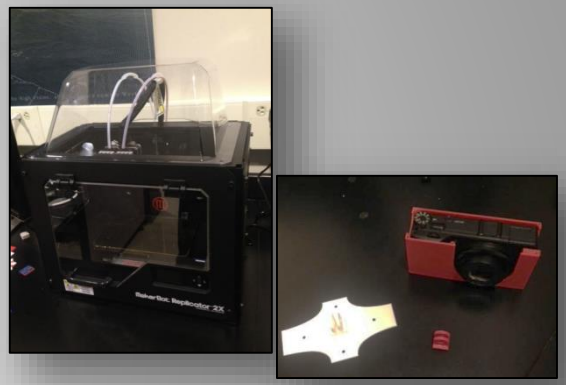
  Near Future: *Santa Cruz, La Crosse, Cape Cod, Reston, Lafayette, Golden*



Future Stategies?

Assistance and Access to Staff

Online Video Technical Instruction

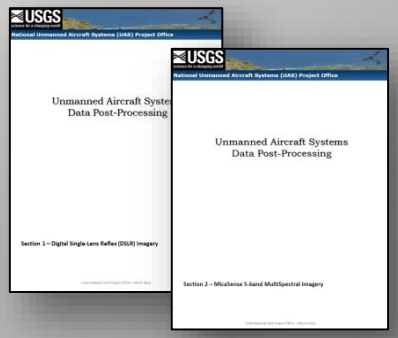


Sensor Mount Designs - 3D Printing

Helping other USGS Centers to get going

Purchasing, Contracting & Training Coordination

Hands-on Workshops



USGS science for a changing world

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